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(54) **Data record with pre-recorded transducer positioning signals, and system for utilizing same.**

(57) A recording member for digital data, particularly a recording tape (10), has a plurality of generally parallel, closely-spaced recording tracks (I-VII) which each contain pre-recorded track-identifying and transducer-positioning servo information, as well as defined data-recording areas (18). The pre-recorded track-identifying information (32, 34) preferably comprises a digitally-encoded individual track address, and the servo information (36, 38) comprises separate bursts used in centring the transducer upon a particular track. Preferably, each such track has a dedicated area (14, 16) at its beginning, end, or both, which contains continuous repetitions of such positioning information, there being no data areas in such dedicated portions. Digital encoding of track addresses utilizes binary-type code format, accomplished by defining a binary "zero" as a recorded burst present at a first number of sampling points, and defining a binary "one" as a burst present at a second number of sampling points of a second duration. The pre-recorded positioning information includes certain non-recorded "gaps" (x) which serve as initializing signals, and the preferred system for utilizing the pre-recorded, servo-controlled record member utilizes peak-detection and minimum-threshold techniques to accurately distinguish unrecorded gaps from noise, or the like, on the one hand, and to distinguish coded signal bursts from other possible recorded signals, or noise, on the other hand. The preferred system is entirely self-clocking, i.e., the record member does not carry a recorded clock track, and thus does not require the additional transducer required where recorded clock tracks are used; at the same time, the area on the record member otherwise occupied by the clock track is available for data-recording usage.

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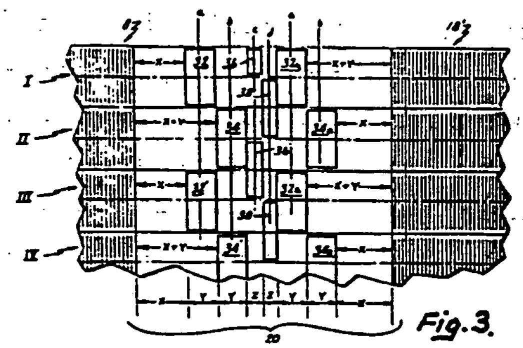

Fig.3.

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DATA RECORD WITH PRE-RECORDED TRANSDUCER POSITIONING SIGNALS, AND SYSTEM FOR UTILIZING SAME

The present invention relates generally to data-recording media, i.e., records, and to record track-following and identifying techniques. More particularly, it relates to improved track-identification patterns and to improved systems for utilizing such patterns, both in track-identification and track-following, and in the recording of data in designated areas along such tracks.

More particularly still, in its most preferred form the invention relates to recording tape for use in data-recording systems, having pre-recorded track-identifying and track-following servo information recorded thereon, together with the preferred systems for utilizing such pre-recorded tape-form record members. In broader aspects of the invention, however, the encoding and decoding techniques for track identification, and the improved record format involved, are also applicable to other forms of record member or media, including discs.

In the use and continued development of data recorders, particularly magnetic recorders, substantial effort and progress continues toward the goal of increasing the amount of data for a unit amount of surface area on the recording media. This involves not only increased bit-packing densities, but also involves substantial increases in the number of data tracks per given area, i.e., the tracks themselves being narrowed, and also being placed closer together.

In the past, the higher range of track densities have been found primarily in the use area of disc-

type recorders, first in large-capacity rigid or "hard" discs, and more recently in some flexible disc applications. While magnetic recording tape has long been used as a data storage medium, a high density multiple-track data storage tape is rarely or never encountered, particularly in business office-type user applications, even though possessing rather substantial potential advantages and benefits. The present invention provides such multiple-track recording tape, together with systems and methods for utilizing the same, in which the multiple data tracks are characterised by the presence of "embedded servo" tracking information, preferably in dedicated areas located near the ends of the tape, as well as at locations disposed along the length of the tape, interspersed with or disposed between data-recording regions.

In achieving high track densities in the use of disc-form media, it has heretofore become known that the recording tracks were rarely perfectly concentric with one another and circular in shape; consequently, when the tracks are very narrow and very closely spaced to one another it becomes necessary to servo-position the transducer, and to employ closed-loop techniques, so that the transducer follows the particular motion of the disc, actually following the motion of the tracks recorded on the disc.

In the case of recording tape, the conditions incident to high track densities and lateral tape "wander", as well as other irregularities of motion

or non-stabilities, have not heretofore been substantially appreciated or well-understood. It is found, however, that recorded tape exhibits its own pecularities of motion as it is transported lengthwise past a transducer, as a result of the seeming impossibility of guiding the tape so continuously and so completely as to maintain this motion in an essentially perfect laterally-fixed position. Of course, recording tape is typically under tension as it is transported lengthwise, and the tape itself is subject to a certain amount of stretching, the amount of which varies as a result of the wide variations in drive forces applied during these conditions. Further, lateral excursions of comparatively large magnitude both parallel to and perpendicular to the transducer may also occur, especially during stopping and starting conditions, as well as during steady-state longitudinal transport. Because of the somewhat random occurrence and presence of such conditions, the non-uniformity of lateral movements of the tape itself, and of recording tracks on the tape, becomes an increasingly important factor as track density increases. Thus, with increased track density, it becomes desirable, and indeed necessary, to servo-control the transducer, moving the same laterally with respect to the tape as the tape is transported longitudinally adjacent the transducer, such that the transducer in effect follows the tracks recorded on the tape even though they may move in a more or less continuous manner with respect to a

fixed reference as the tape passes the transducer, or head.

Thus, while there are certainly some general similarities or analogous points involved in magnetic recording on discs as compared to tapes, there are fundamental differences which to a considerable degree isolate the two different activities from one another. That is not only true with respect to the types and natures of the inaccuracies or irregularities of motion, but is also true with respect to conditions for servoing the respective recording media. For example, in the case of disc recorders, it has long been an accepted practice to use at least one track, and frequently either additional tracks or one entire side of a disc (in a multi-disc environment) exclusively for permanently-recorded clock and servoing information or signals. In such situations, a completely separate transducer head is also utilized, being dedicated to clocking and/or servoing activities, and not used for other purposes such as data recording or replay. Since most recording tape is relatively narrow, where multi-track arrangements are desired it is antithetical, and undesirable, to dedicate an entire track or area for permanent use as a source of servo or clock signals. Of course, the provision of a dedicated transducer head for such purposes it also undesirable from the standpoint of economics, at least, and the use of such a head also may present strictures or difficulties from a packaging or placement standpoint,

particularly in the case of tape, which is narrow in width and which has most of its length in an unaccessible position, i.e., wound upon reels of one type or another. Consequently, other approaches become highly desirable, if not mandatory, consistent with the particular conditions presented by the nature of recording tape and its environment.

In considering the general development of record track-identification and following systems, generally as an adjunct of high track densities and narrow track widths, prior developments which have taken place in disc-recording technology are to some extent helpful; however, as pointed out above, the inherent nature of tape-recording techniques, of the tape media itself, and of particular conditions mandated thereby, combine to present their own particular problems. For example, recording tape often commences motion from a rest position, which may either be at one end of the tape or somewhere between the ends thereof; furthermore, tape drive motion may in many instances be bi-directional, or various bands or tracks on the tape may be intended for a first direction of motion, whereas other bands or tracks are intended for the opposite direction of motion. Thus, "embedded servo" techniques developed for use in disc applications may well not be applicable, or may raise quite different problems if applied.

The present invention provides novel and advantageous servo record format techniques which are especially advantageous for use in multiple-track,

high-density tape recording applications, particularly magnetic tape; in its broader applications, however, the novel servo-recording formats are also useful in other media types, including for example, recording discs.

According to one aspect of the present invention, there is provided a servo-tracking data record member having the capacity to record and retain signal transitions recorded thereon, and having a plurality of generally parallel recording tracks comprised at least in part by lines of pre-recorded, dedicated tracking records, said tracking records comprising a digitally-encoded header portion embodying a coded signal pattern uniquely identifying the particular recording track embodying that header, and said tracking records further comprising track-centring servo signals including at least a pair of amplitude-encoded signal transitions disposed on opposite sides of each such track at a predetermined position along the recording track with respect to the said header.

According to a second aspect of the present invention, a method of identifying a particular one of a number of generally parallel recording tracks disposed laterally adjacent one another and extending longitudinally in the direction of motion of a movable record member, and centring a transducer upon the identified track, is characterised by: transducing sequentially-repetitive header signals recorded along a given track of said recording member, to reproduce such signals; sampling the said reproduced signals at

predetermined intervals to determine a particular signal parameter at such intervals; digitally assembling the signal parameters so determined to form a digital code symbol; comparing said code symbol to a reference symbol which uniquely identifies a particular recording track, to determine whether said given track from which signals have been transduced corresponds to said particular track; and, at least in significant part as a function of the said determination made by said comparing step, thereafter detecting servo-positioning signals recorded generally along said given track, and utilizing such signals to centre a transducer upon said track.

Other aspects of the invention are set out in Claims 15, 16 and 19 and preferred and advantageous features are set out in the subsidiary claims. However, certain preferred features will be highlighted in the following discussion.

The present invention provides an advantageous track-identification encoding technique, which makes use of binary-type, digital addresses for each different track, which is integrated with servo-positioning records, which provides for high reliability in code pattern recognition and decoding reliability, with resultant highly reliable track identification.

Additionally, the present invention provides highly useful detection and decoding techniques which increase the system reliability while also maximizing the available number of recording tracks, and at the same time, providing desirable system design and

manufacturing economies.

Some of the more particular objectives, advantages and features of the invention are: to provide a highly effective embedded servo record member, and system, for use in tape-type devices, while at the same time having broader applicability and usefulness in other forms of recording technology; to provide dititally-encoded indivitual track addresses as part of the pre-recorded positioning patterns, and to integrate such recorded track addresses with track centring servo information; to provide for a track-identification and track-following record format making use of erased gaps, i.e., signal absences, as significant record-detection and timing features; to provide for the use, in such a system, of only a single transducer for track-seeking, for track identification, for track-following, and for data recording and reproducing purposes, i.e., totally dispensing with the need for, and use of, a separate, dedicated clock track, as well as a separate, dedicated servo track, together with elimination of the concomitant feature of a separate, dedicated transducer such as is typically employed where separate clock tracks and/or separate servo information tracks are utilized.

Additional features of the invention are the provision of highly advantageous threshold-detecting and/or peak-detecting concepts, used both to verify the presence of various code pattern features, as well as to process transduced code signals; the provision of non-aligned and non-registering track-positioning

(i.e., track-identification and track-following) signal records on a lateral track-to-track basis; the provision of a track-positioning system which provides for self-clocking not only of servo-positioning records but also of data information records, and for the updating or re-synchronizing of such clocking on a record-by-record basis; and, the provision of a formatted, multiple track record member having designated beginning and/or ending portions of the various tracks which are dedicated to, and contain substantially only, track-identifying and track-following record signals, appearing on a generally continuously repetitive basis.

The invention may be carried into practice in various ways but there will now be described by way of example one tape with servo-tracking information thereon, together with the method and a system for utilizing this information, all in accordance with the present invention. The description is made with reference to the accompanying drawings, in which:

Figure 1 is a fragmentary, pictorial view of one example of a record member in accordance herewith illustrating the general placement of the positioning information recorded thereon;

Figure 2 is an enlarged, fragmentary view showing a portion of one of the dedicated end areas of the record member of Figure 1 and indicating the general placement and format of the recorded tracking information contained in such areas;

Figure 3 is an enlarged, fragmentary view showing

a medial portion of the record member of the preceding figures, showing a single positioning information record, interspersed between data records;

Figure 4a is a pictorialized signal wave form diagram illustrating track identification address encoding techniques, and Figure 4b is an envelope representation of the wave form of Figure 4a, further illustrating decoding techniques;

Figure 5 is a block diagram illustrating the general system for utilizing the pre-recorded "embedded servo" positioning information provided on the record member;

Figure 6 is a first schematic diagram illustrating further details of a first position of the block diagram of Figure 5; and

Figure 7 is a second schematic diagram illustrating details of a second portion of the block diagram of Figure 5.

Figure 1 is a fragmentary, pictorial view of one example of a record member in accordance herewith illustrating the general placement of the positioning information recorded thereon;

Figure 2 is an enlarged, fragmentary view showing a portion of one of the dedicated end areas of the record member of Figure 1 and indicating the general placement and format of the recorded tracking information contained in such areas;

Figure 3 is an enlarged, fragmentary view showing a medial portion of the record member of the preceding figures, showing a single positioning information record, interspersed between data records;

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Figure 6 is a first schematic diagram illustrating further details of a first position of the block diagram of Figure 5; and

Figure 7 is a second schematic diagram illustrating details of a second portion of the block diagram of Figure 5.

Referring now in more detail to the drawings, Figure 1 depicts a servo-tracking data record member 10 in accordance with the invention, which in the most

preferred form is magnetic tape, in particular, relatively narrow tape of the type typically provided in cartridges or cassettes; for example, "one-eighth" inch tape, which is actually .015 inch (3.81 mm) wide. Such a record member may, in accordance herewith, carry a plurality of generally parallel recording tracks, indicated generally in Figure 1 as horizontally-extending spaces delineated by lightly-drawn horizontal lines. More particularly, seven such separate tracks are illustrated herein (Figure 2), although a larger number than that could actually be implemented on eighth-inch tape by practicing the invention. Thus, the tracking difficulties caused by vertical tape wander during end-to-end transport will be readily apparent.

The record member 10 as depicted in Figure 1 generally includes leader-type end portions 12 and 13, typically of non-recordable character, and typically carrying punched holes or the like 12a, 13a, which serve as beginning-of-tape ("BOT") and end-of tape ("EOT") indicia, respectively, conventionally detected by optical means. The record member 10 is formatted to have dedicated or restricted areas 14 and 16 at the beginning and end of the tape, respectively, which are devoted exclusively to the presence of pre-recorded tracking information, explained further hereinafter. Additionally, the record 10 includes a large plurality of record fields 18 which may be considered to be segregated or demarked from one another by recorded indicia, i.e., recorded signal patterns or conditions,

appearing in blocks designated by the numeral 20, described more fully hereinafter.

The dedicated area 14 of the record member 10, mentioned briefly above, is shown in more detail in Figure 2, wherein the different recording tracks are designated I-VII, inclusive. As schematically illustrated in Figure 2, each individual such track in area 14 (as in area 16) has a repetitive pattern of the signal blocks 20, each of which may for purposes of illustration be subdivided by the vertical indicia or ordinates a, b, c and d. Further, the odd-numbered tracks I, III, V, and VII are essentially identical, as are the even-numbered tracks II, IV and VI. While the odd-numbered tracks are similar to the even-numbered ones, they are organized somewhat differently, as discussed hereinafter, and it will be observed that the recorded blocks in the odd-numbered tracks are not in lateral registration (i.e., not aligned along the ordinates a-d) with the analogous blocks in the even-numbered tracks.

As already indicated, the major portion of the record member 10 is formatted to have repetitive, alternating record fields 18 which are set apart from one another by what have been referred to as recorded indicia blocks 20; in fact, the latter comprise what may be referred to as "servo burst" fields or "positioning records", which include an encoded track-identification address and servo-positioning tracking signals, or blocks of signals. This general format is illustrated schematically in Figure 3, in which successive data

record fields 18, 18' are shown in a representative way to include a large number of closely-spaced signal transitions, which may for example be on the order of eight kilo bytes, typically including not only user data per se but also such things as field markers, headers, error check codes, etc. It is contemplated that the various record fields 18, 18' are written in modified FM (MFM) according to conventional data-writing techniques. The servo fields 20 are another matter, however, and the preferred format for these is illustrated in Figure 3.

As shown in Figure 3, interspersed between each of the various record fields 18, 18', in which the user's data is recorded, are the aforementioned "servo burst" fields 20. In fact, each such servo burst field 20 includes several distinct signal records - in particular, an encoded track-identifying header block 32 (odd-numbered tracks) or 34 (even-numbered tracks), followed (as viewed from left to right) by first and second servo-positioning bursts 36, 38. The header blocks 32, 34 are centred upon the centreline of each of their respective recording tracks, but the servo-positioning bursts extend in opposite directions with respect to such centrelines and are disposed in immediately-sequential relationship along the track, i.e., one immediately following the other along their track.

More particularly, it should be noted first that whereas in the illustrated embodiment each of the data fields 18 in each adjacent track terminates at the same point along the tape, on a track-to-track basis,

such lateral registration is not in a strict sense an absolute requirement of the present recording pattern and system. The depicted coterminous arrangement does, however, serve to illustrate a likely or even a preferred pattern or arrangement, and helps to illustrate certain characteristics of the servo burst blocks. Concerning the latter, it will be noted that certain particular erased gaps (i.e., non-recorded segments) are located at the end of the user's data blocks 18, i.e., at the start of each of the servo blocks 20. More particularly still, one type of such a gap, designated "x", appears in the odd-numbered tracks between the end of data fields 18 and the header blocks 32. A different and longer erased (i.e., unrecorded) gap exists between the end of the user's data blocks 18 and the even-numbered tracks and the position of the first header blocks 32 to the right in those tracks. The length of this second type of gap equals the length of gap "x" plus the length "y" of header 32; thus, the second such gap has a length of x plus y. Thus, for example, representative such tape lengths, in terms of time (neglecting speed variations), may be: gap x = 4 milliseconds, duration y (which is the length of the header blocks 32, 34) = 2.2 milliseconds, and duration z (which is the length of the track-following servo bursts 36 and 38) = 1 millisecond. These relative durations are approximated in a proportional sense by the corresponding blocks depicted in servo burst 20 in Figure 3.

With further reference to Figure 3, it will be

noted that in the odd-numbered tracks, such as tracks I and III, a second track-identification header 32(a) appears to the right of the second servo burst 38, leaving an unrecorded gap of a duration x plus y between the end of header 32(a) and the block of user's data 18' immediately to the right. In the even-numbered tracks, a second header block 34(a) is also present within each servo burst area 20, and is located to the right of the second track-positioning servo burst 38, but at a distance therefrom corresponding to gap y. Thus, between the right-hand edge of each header block 34(a) in the even-numbered tracks and the next block of user's data 18' to the right, there is an unrecorded gap of a duration x.

It will thus be seen that the "positioning information" components (i.e., both the track-identification and the track-following signal blocks) in the servo block 20 of the odd-numbered tracks are all similarly positioned, and the counterpart information, or recorded signals, in each of the even-numbered tracks is analogously, but differently, positioned; i.e., the recorded signal blocks in the odd- and even-numbered tracks are in a sense complementary, but they have specifically differing locations. In the first place, the header blocks 32 and 34 are not laterally aligned on a track-to-track basis, but instead follow one another successively from the standpoint of track length. Thus, the odd-numbered tracks have a gap x between the end of the user's data blocks and the first header block 32, whereas in the case of the even-numbered

tracks, there is a gap of length x plus y in that position; conversely, after the last (second) header block 32(a) in the odd-numbered tracks and the next ensuing block of user's data 18', there is a gap of a duration x plus y, whereas in the analogous position in the even-numbered tracks there is a gap of only duration x. It may thus be seen that the recorded signal pattern in the servo burst 20 in odd-numbered tracks takes the following form, from the standpoint of duration: an unrecorded or erased gap x, a header burst of duration y, an unrecorded gap of duration y, a positioning burst of one polarity for a duration z, a second positioning burst of the opposite polarity for a duration z, a second header for a duration y, and an unrecorded gap of a duration x plus y. In the even-numbered tracks, the burst-gap pattern is the reverse. This basic pattern or format may be used as a preliminary or overall synchronization pattern, to provide a check which ensures that a given pattern of signals transduced from a given record track is, in fact, a servo burst block 20, i.e., failure of the synchronization pattern at any point along its length resulting in microprocessor-controlled reinitialization of the servo loop and circuitry.

An exemplary track-identification header 32 occurring over the duration y is illustrated in more detail in Figures 4a and 4b, the basic nature of which generally characterizes any of the header blocks 32 or 34 (or, as explained more fully herebelow, the header blocks 32(a) and 34(a). As illustrated in Figure 4,

the period or duration y (in the specific example given above defined as having a duration of 2.2 milliseconds) is in effect subdivided to form six bit cells A-F inclusive (each thus having a duration of 370 microseconds). During each such bit cell, a burst of uniform-frequency signal is recorded (for example, square waves at a frequency such as 100 kHz). The duration of these bursts, or their presence at successive sampling points, in accordance herewith, determines whether the bit cell has a logic value of a binary zero or a binary one. More particularly, in accordance herewith, the detected headers 32, 34 are sampled or detected, a number of successive times (preferably at regular intervals commencing asynchronously) during specified divisions (for example each one-third) of each total bit cell duration. Representation of typical sample points are shown individually, for purposes of illustration, in Figure 4b by the arrows A(1), A(2), A(3), B(1), B(2), B(3) etc., each of which may be understood to represent a spaced grouping of different distinct samples occurring during that bit cell. As explained more fully hereinafter, the preferred sampling technique is to employ peak-detecting means and to selectively enable such means a desired number of times at regular intervals during accurately-timed bit cells, by microprocessor control.

However particularly accomplished, the sampling or detecting process will be seen to produce a resultant binary-type coded signal grouping. With reference

to the signal pattern depicted in Figure 4a, and sampling or detecting at various points as aforementioned, if a binary zero is the value ascribed to a signal-present condition existing at a first detection point (for example, A(1)), but absent at the next two ensuing points (A[2] and A[3]), such as is true of bit cells A, B, D and F, and ascribing a binary one value to the situation where signal presence is detected at both of the first two such sampling points, but not at the third such point, as is true for example in bit cell C and bit cell E, the resulting encoded address for the header 32 depicted in Figure 4 would be 001010. In each case, the third sampling area is used as a code-verifying means, the presence of a signal burst during that sampling area indicating a false or non-authentic code signal, and thus not an operative header.

Of course, the particular address header duration y utilized in a given system may be made to correspond to the particularities of that system, insofar as requisite number of binary bits, etc. In accordance herewith, however, using an odd-even pattern format corresponding to odd-numbered and even-numbered tracks, as described above, it may be desirable to dedicate certain bit cells to an indication of whether an odd track or an even track is being received. This may be accomplished, for example, by use of a particular one of the bit cells, for example bit cell A, encoding the same to have, for example, the binary zero illustrated in Figure 4 as an indication of an odd-

numbered track, a binary one being used to indicate an even-numbered track. Alternatively, this information may be obtained directly from the track identification code, since inevitably an identified specific track will be known to be odd or even, as the case may be. It is further useful to indicate the relative position of the particular bit cell being read with respect to the general arrangement of the entire track, i.e., whether or not that bit cell, and thus the position of the tape with respect to the head at that instant, is at one of the dedicated portions 14 or 16 at the ends of the recording track, or one of the medial positions somewhere between these two areas. This may be accomplished by the encoding of a second bit cell, or the first and second bits may both be utilized for this purpose, to provide for greater detection assurance or parity check purposes.

In accordance with the preceding, it will be seen that the header-recording format thus embodies an encoding technique which provides for digital track-addressing, of a binary code form. That is, not only may certain bit cells be designated to carry general information, (e.g., odd or even track, as aforementioned), but a group of bit cells may similarly be designated to carry a binary address for the particular track being transduced. In the example given in Figure 4, if the first two bit cells are dedicated for generalized positioning information in the manner set forth above, four bit cells remain for a binary address for the particular track then being transduced. Of course,

additional bit cells could be provided for in the headers by which, for example, an address could be similarly encoded for the particular position along the recording track, for example, the particular sector, which information is highly useful, and perhaps essential, in the case of very lengthy record tracks. In such a case, all or any desired part of the entire header format may, from the standpoint of signal or gap sequencing, be used as a synthronization pattern, to augment system accuracy, and in fact the entire encoded header, or a desired portion thereof, may be repeated or presented in complement form for synchronized or recognition purposes.

The servo burst format illustrated in Figure 3 is deemed particularly advantageous in the case of tape-form record members, as contemplated hereby. More particularly, in a multi-track tape-form record member, end-to-end, back-and-forth data recording and reproduction is highly advantageous. Thus, a two-gap transducer head which is positioned with one gap in alignment with an odd-numbered track and the other in alignment with an even-numbered track, e.g., tracks I and IV, may transduce from the first such track with its upper gap while the tape is first transported from left to right, and when the tape reaches the end, the transducer may simply remain in its position and leave its other channel enabled to read or write on track IV of the tape as it is transported in the opposite direction.

In such a system, the header encoding for headers

32 and 34 may be accomplished in a left-to-right sequence, whereas the encoding of headers 32(a) and 34(a) may be in a right-to-left, or reverse, sequence. That is, while a sequence of logic zeros and ones will indeed identify a given particular track, the logic sequence will be different depending upon whether it is being read from the left or from the right, and it may at times happen that the enabled transducer gap is aligned over a track then being moved in the "wrong" direction. Thus, if an "erase" (i.e., unrecorded) gap of *x* plus *y* duration is the first thing encountered or "read", the transducer could either be positioned over an odd-numbered track with the tape being transported from right to left, or it could be positioned over an even-numbered track with the tape being transported from left to right, the mere occurrence of a verified six-bit address header not in and of itself necessarily indicating actually meaningful information. If the address headers positioned at what should be the end of the servo burst block, (i.e., headers 32(a) or 34, in a back-and-forth or alternating track-recording sequence) are encoded in reverse format, the track address which they embody will be properly "read" and "understood" by the system, and the actual direction of record member motion may thus be accommodated and/or verified.

The servo-positioning bursts 36 and 38 are, in accordance herewith, contemplated as being bursts of uniform-frequency signals, of approximately the relative duration indicated previously (i.e., of the order of

one millisecond) and generally depicted in Figure 3. As seen there, each such servo-positioning burst is disposed over one-half of two adjacent tracks (except, of course, for the edge tracks such as that designated track I). Thus, servo bursts 38, for example, will be "read" by a transducer centred on track I and also read by a transducer centred on track II, and the same is true of a servo-positioning burst such as burst 38', which is shared between tracks III and IV. Similarly, servo-positioning bursts such as 36' are shared between tracks II and III. Compared to the duration of each individually-detected bit cell in the headers, it will be appreciated that the continuous servo-positioning bursts are of long duration, i.e., approximately three times the length of each header bit cell. This not only provides for virtually certain detection of one from the other, but also provides for considerable certainty in the accurate detection of the particular amplitude transduced from each servo burst, during positioning, as described subsequently.

The track-identifying headers 32, 34, unlike the servo bursts 36, 38, are each centred upon their own respective recording tracks, and are not shared between, or read by, a transducer centred upon the adjacent track. Also, it will be noted that while the header records are approximately a full track width wide, they are not aligned laterally from track to track, but are instead offset from one another with respect to the track length. Thus, a transducer located between tracks

I and II, for example, will first read the lower half of header 32 and then the upper half of header 34, thus maintaining the integrity, and understandability, of the digitally-encoded track identification embodied by each respective header. That is, binary-encoded track address bits from two separate tracks will not be read at the same time, or during the same time period.

The servo-positioning bursts 36, 38, being comprised of single-frequency and single-amplitude signals, thus constitute amplitude-type transducer-positioning embedded servo information, detection and use of which may be utilized to centre a transducer upon a selected track, and to maintain the transducer in such a centred relationship, generally through known amplitude-comparison techniques. That is to say, a transducer generally aligned with track I, for example, will (after encountering erased gap x and track-identifying header 32) first encounter servo burst 36 and then encounter servo burst 38. If the transducer is at that time more nearly aligned with burst 36 than it is with burst 38, a difference in amplitude will be detected, and that difference may be utilized to generate an error signal which, by closed-loop servoing techmiques, may be used to move the transducer an indicated amount in an indicated direction to bring it more nearly onto the track centre, directly between the two servo bursts.

In accordance with the foregoing, it will be seen that the servo burst area 20 is encoded so that (where

the odd-numbered tracks are read from left to right, and the even-numbered tracks are read from right to left) a transducer head following generally along a recording track will first encounter an erased or unrecorded gap of duration x, will then encounter a digitally-encoded track-identifying header of duration y, will then encounter an erased gap of duration y, will then encounter a servo burst of duration z which is representative of positioning in the direction corresponding to the upper portion of the recording track (as depicted in Figure 3), will then immediately encounter a second servo burst of duration z representative of positioning in the direction corresponding to the lower half of the recording track, and will then immediately encounter a reversely-encoded track-identification header of duration y. Following that, the next thing to be encountered is an unrecorded gap of duration x plus y, followed by the next ensuing block of user's data 18', which would, of course, be recorded left to right in the odd-numbered tracks and right to left in the even-numbered tracks.

Referring once again to Figures 1 and 2, and particularly to the dedicated areas 14 and 16 at the beginning and end of the record member (or at least the beginning or end, or at a designated position along the length of, particular record tracks), as indicated previously, such dedicated areas preferably comprise continuously-repeating servo burst blocks of the type generally designated by the numeral 20 in Figure 3. The feature of a dedicated area 14 or 16 is particularly

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advantageous in the case of a record member 10 comprising recording tape, especially where the intended or most frequently-expectable mode of use is where the tape begins motion at one end; most typically, running in a continuous motion until the other end is reached, although intermittent motion during medial portions of the tape is also a possible procedure.

In either event, a dedicated area 14 of the beginning of the record member or record tracks helps ensure that upon start-up of motion, or of recording or reproducing activities, the particular track upon which the transducer is then most closely centred may be identified with complete certainty, and a desired or selected track may be located and centred upon, prior to the point where the transducer encounters the user data fields 18. After that time, the interspersed singular track-positioning fields 20 may be relied upon to maintain the transducer centred upon the identified track. Particularly where the record member 10 is in the form of tape, however, upon start-up of motion it is desirable to have more than one (or a very small number) of the positioning fields 20 for the desired degree of certainty in initial track-seeking and track-following operations. Accordingly, each of the dedicated areas 14 and 16 may comprise a relatively lengthy portion of record track, for example, of the order of as much space as might contain, say, 100,000 bits of user data as written in its customary format, and even more, preferably from three to five times that amount. With respect to the showing contained in

Figure 2, it should be noted that such showing is to some degree merely illustrative, since while generally an accurate representation, the same lacks some of the detail set forth in Figure 3. Thus, it should be understood that each of the blocks of positioning information 20 generally depicted in Figure 2 does in fact comprise one of the servo burst blocks 20 illustrated more particularly in Figure 3.

A preferred, or exemplary, system for use in implementing a servo-tracking record member and track-positioning means in accordance herewith is illustrated in block schematic form in Figure 5. Referring to that figure, it will be seen that the same depicts a closed-loop servo system in which a transducer or head 40 is mounted for cam-actuated bi-directional movement, under control of a rotary cam 42, which in turn is driven by a stepper motor 44. To depict a generally typical stepper drive environment, four different drive paths are shown leading to the stepper motor 44 from stepper drive means 46, which receives a like number of commands through a port expander 48 from a microcomputer 50, the stepper drivers 46 also receiving an input from a counter-timer 52. The microcomputer 50 embodies, or is coupled to, a controller 54, (for example, the user's data entry system controller) from which it receives commands and to which it communicates program and condition status. Microcomputer 50 also provides an output 55' directed to the tape transport or other such record drive, typically power-switching control means for an electric motor.

In its transducing operations, the head, or transducer 40 "reads" recorded transitions on the record member 10 and provides representative electrical signals through a "read electronics" circuit 56, which may for example include an operational amplifier, filter, buffer amplifier and a rectifier. The latter circuit communicates through a read channel 66 with, and is monitored by, a peak detector 58, to be commented upon in more detail subsequently, but which basically provides the sampling function indicated at points A(1), A(2), etc., shown in Figure 4b and discussed above in connection therewith. From the peak detector 58, the servo loop is coupled to the microcomputer 50 and the counter-timer 52 through an analog-to-digital converter 60 and a multi-channel data bus 62, the "A/D" converter 60 serving to change the analog signals in the read channel to digital signals in the computer and controller portion of the servo loop. As indicated, the analog read electronics circuitry has an output 57 leading to the user's data read system; thus the "read electronics" 56 actually serves multiple purposes.

As additionally indicated in Figure 5, the microcomputer 50 also receives an input 64 which, as labelled, comprises signals for the beginning-of-tape ("BOT") and end-of-tape ("EOT") sensor, which may be conventional in nature (e.g., optical) and serve to detect the holes 12a and 13a in the respective ends of the record media, where that is a tape of the type indicated in Figure 1. Of course, other types of such end-of-

record and beginning-of-record (or sector) indicia and sensing means are known, and as indicated above such a sense or indication may also be obtained from direct digital encoding on the record media itself. Whichever particular means be utilized, the resulting signal is of rather fundamental importance, at least for tape drive start and stop operations and, at least potentially, as an initial timing signal.

The system shown in the Figure 5 block diagram is illustrated in more detail in Figures 6 and 7, and reference is now made to all three such figures. Considering first the signals read from the recording member 10 by the transducer 40, the input channel 55 carries transduced signals to the "read electronics" 56, whose output is coupled on channel 66 to the peak detector 58, initially in the form of a two-path differential signal ("BFRD1" and BFRD2", i.e., "buffered read 1" and "buffered read 2") (Figure 6), which is coupled through a differential single-ended-output amplifier 68, and then to a pair of successively-coupled operational amplifiers 70 and 72, whose output is applied directly to inputs ("A in" and "B of S") of the analog-to-digital converter 60. Basically, the peak detector 58 thus comprises the operational amplifiers 70 and 72, three diodes 74, 76 and 78, and the capacitor 80, which are coupled to the plus input of amplifier 72. Essentially, that circuitry comprises an interface for an FET switch/gate 82. The latter comprises the main portion of what may be considered a sub-unit of the peak detector, i.e., a "capacitor dump"

unit, or stage, which directly controls operation of the peak-detecting capacitor 80, and thus plays an important part in the specific operation of the overall system. Control of the FET switch 82, in turn, is effected by an output 84 ("CDUMP") from the micro-computer 50 (note Figure 7).

The output from the peak detector 58 is coupled to the analog-to-digital converter 60, as already noted in conjunction with Figure 5. This is shown in more detail in Figure 6, in which the A/D converter 60 may be seen to preferably comprise an integrated circuit ("IC"), which may be implemented by the commercially available IC chip designated as an AD7574JN. As illustrated in Figure 6, one side of the peak-detecting capacitor 80 is coupled to an input of the peak-detector amplifier 72, the output of which is coupled on a circuit path 88 to the above-noted inputs of the A/D converter 60. The other side of the peak-detecting capacitor 80, to which is connected one side of a voltage-reference element 86 (which may be an IC chip AD581) is applied to a "ground" input ("AGND") of the A/D converter 60.

As already indicated, outputs from the analog-to-digital converter 60 are coupled to microcomputer 50, and also, via bus 62, to the counter-timer 52. The latter component is shown in more detail in Figure 6, and may be implemented by an IC chip 8253. This type of counter-timer chip has a number of internal counters available as outputs, a first one of which, on port 89 ("SYNC"), is used as the frequency for a pulse-width-

modulated signal which ultimately energizes the stepper motor 44, i.e., that counter signal sets the period of such pulse-width-modulated signal. A second counter output appearing on output port 90 of counter-timer 52 ("TPLS") is used to establish (i.e., modulate) the width of the pulse just mentioned, i.e., that coupled to the stepper motor. A third counter output, on port 92, provides a control signal ("TBLCK") for timing ("windowing") the occurrence and duration of anticipated recorded blocks of signals, e.g., servo positioning bursts and user data blocks.

As indicated in Figure 6, the A/D converter 60 also interfaces (on its ports "DBØ" - "DB7" inclusive) with the similarly-labelled counter-timer 52 ports, and with the microcomputer 50 on its tape bus ports, i.e., ports "TBØ" - "TB7" inclusive. The counter-timer 52 also communicates with the microcomputer 50 through the ports, and channels, labelled "TMRRD" (i.e., timer read), "TMRWR" (i.e., timer write), "TMRCS" (i.e., timer chip select), "TMRA1" (i.e., timer address 1), and "TMRAØ" (i.e., timer address data).

The microcomputer 50 (Figure 7) is preferably an Intel 8041A, which is a single-chip device having one kilobyte of ROM and sixty-four bytes of RAM internally. As indicated, the microcomputer has three groups of port ends 94, 96 and 98, the first of which comprise individual controls directed variously to the peak detector, the A/D converter, the counter-timer, etc., as may be understood by the mnemonic labels attached

to each such output and to the ports respectively coupled thereto. With respect to these microprocessor ports, it should be pointed out that the one labelled "TBEN" provides a tape bus, or data bus, enable signal for the bus, or port grouping, designated by the numeral 96. Other ports possibly not heretofore specifically referred to include that designated "ADRD" and that designated "ADCS", both of which couple to the similarly-labelled ports of the A/D converter 60 and provide A/D read signals and A/D chip select, respectively. The second such port grouping 96 comprises a tape bus, or more broadly, a data bus, coupled to the first eight output pins of the A/D converter 60. The third such microprocessor port grouping 98 comprises a third bus which may be considered an interprocessor channel which couples to the controller 54 (which may be a master microcomputer comprising part of an intelligent terminal or computer controlling an entire data system of which the present storage device is merely a part).

As will be understood, the port-expander 48 is in a sense merely an accessory device, which allows the addition of input/output ports for the microcomputer 50, particularly when the latter comprises the chip 8041, as indicated above. Accordingly, the port-expander may for example comprise an 8243 (Intel), which is made for that purpose. Corresponding connections between the port-expander 48 and the microcomputer 50 will be apparent from the pin designations to be found in the drawings. Port-expander outputs are also

mnemonically designated, and may broadly be considered as tape (or other record member) status and motion control outputs "TRUN" providing a tape run command, "TF/TR" providing a tape forward-tape reverse command, "CHANA" providing a head channel select command, "CPRES" providing a record-present or record-in-place sensor signal, and "WPROT" providing a write-protect command (outputs such as "CDUMP", "TBLCK", and "TBEN" having already been discussed).

The stepper motor driver 46 may, as illustrated (Figure 7), comprise discrete logic components and driver (power) transistors for energizing the coils of the stepper motor 44. Such driver circuits are, of course, well-known and often utilized, and require no particular detailed discussion. Within the driver unit generally designated 46, the two identical arrays of AND gates 100, 101 may be comprises of the commercially-available chips designated as 74LS33. As indicated previously herein, the general process or procedure of stepper motor-control known as "microstepping", by which essentially continuously-variable movement is effected, is a known technique. Insofar as the pulse-width modulation stepper motor drive approach is concerned, it will be remembered that the output designated TPLS from the second counter of the counter-timer 52 provides the pulse-width modulating command, the counter-timer being a programmable device subject to microcomputer control, such that the pulse-width actually coupled to the stepper motor is under continuous microprocessor control, the system operating in the general

manner of an astable multivibrator.

In the overall operation of the system, the basic desired end is, of course, to commence motion of the tape or other record member 10 relative to the transducer head 40, move the head to and centre it upon a particular one of the various recording tracks I-VII inclusive, determine the relative position of the transducer along such track, and read or write data in the various user's data blocks 18, 18' along the particular desired recording track while continuing to read the track identification and, by monitoring the periodic servo positioning bursts, to maintain the transducer head centred upon the desired track as the tape moves along beneath (i.e., adjacent) the continuously-servo-positioned transducer head.

Initially, it is to be anticipated that, if the record member is a tape, beginning movement will typically commence with the head 10 located generally over the beginning leader portion 12, (or perhaps over the ending portion 13), in some position between the lateral edges of the tape at such location. Toward this end, the system may include any of a number of means, or measures, to position the head at a given "home" or starting position whenever the system is shut down (or loses power), or whenever it is started up again after having been shut down. For example, the stepper motor may be driven to a given location or against a stop under such conditions, thereby bringing the cam, and transducer, to a particular home position, generally aligned over a track closest to one

edge, e.g., track I. Such measures are in general known and need not be particularly discussed, as is also true of techniques for moving a transducer head to a given general area of the record, or to a particular track represented by an inputted address or command.

In any event, the initial function of the system, once the tape is moving, will be to "look for" BOT/EOT signals on input 64 to the microcomputer 50. Once the appropriate such signals are received and correlated with a corresponding sync pattern in the microcomputer memory (to determine whether the tape is at the beginning or end), the next anticipated signals from the read electronics 56 will be the continuously-repeating servo burst blocks 20 from the dedicated area 14 (or 16) at the beginning (or end) of the various record tracks. Thus, the microcomputer will, after receiving BOT/EOT signals, initialize the system to "look for" an erased gap of duration "x", which will be detected by the absence for that particular time interval of transduced signals in read channel 66 of a magnitude greater than that set by voltage reference stage 86 as a minimal threshold for activation of the peak detector 58. That is, signals less than that threshold level, whether actually an erased gap, noise, or low-level recorded transitions of undetermined origin, will be considered as unrecorded gaps, or non-recorded areas. Transduced signals in the read channel exceeding that minimum threshold level will activate the peak detector, assuming enablement (actually,

lack of disablement) by microprocessor 50 on gating input 84 of the peak detector.

More particularly, the system will require sequential detection, within the known particular time intervals, and by the peak-detector threshold technique just related, of the servo burst format shown at 20 in Figure 3 and discussed above, including the erased gap "x" preceding a header block 32, followed by an erased gap of duration "y", followed by the two servo-positioning bursts 36 and 38, followed by a six-bit reversely-coded header 32(a) and a gap of duration "x plus y". As the transducer head is traversed by an odd-numbered track of the moving record member during the dedicated portion 14 of the record, this repeating pattern will be detected, affording an opportunity for the peak-detecting procedure discussed in conjunction with Figures 4a and 4b, with resultant decoding of the digitally-encoded track address. Also, there will be the repetitive detecting and utilization of the servo-positioning bursts for track-following (centering) purposes.

As indicated previously, the microprocessor program should be such that so long as the correct sequence of signal types corresponding to the servo block recording format continues to be received at the correct time intervals, the detecting and track-following process continues, the decoded logic levels from the various bit cells in the header blocks being sequentially stored and, when assembled into a binary-form track address, compared with a desired track address

inputted to the microprocessor by operation of the system controller 54. In general, it will be appreciated that a logical decision may then readily be computed by the microprocessor if the detected header address is not the desired one, directing the stepper driver and stepper motor 46, 44 to move the cam 42 the appropriate amount in the appropriate direction and thereby reposition the head 40 over the proper track. If it should ever happen that the head is positioned over an even-numbered track upon start-up, with tape movement from left to right (or the opposite such circumstance, i.e., odd-numbered track and right-to-left movement) a "reversely-encoded" header will probably be read and the situation corrected by the microprocessor algorithm. If not, the tape would merely run its length without header decoding and stop when EOT signals were received, whereupon reverse-direction motion would resolve matters, proper header decoding, etc. taking place. During the continuously-repetitive positioning information in the dedicated areas 14 or 16, the track-identification and track-seeking process will be completed, with servo-tracking in effect when the transducer encounters the first block of user's data 18, whereupon the user may write or read data, depending upon commands inputted by the controller 54, and the transducer position will be maintained on track by the periodic embedded servo blocks.

In this procedure, it is important to note that the programmable counter-timer 52 is utilized, via the microcomputer 50, to time out the various different

intervals into which the record member is formatted by its pre-recorded servo blocks 20, and also to time out the user data blocks 18, 18' between which the servo blocks are placed. That is, if signals of the appropriate level are received during the appropriate timed intervals, the detecting sequence continues; otherwise, the system is re-initialized (by command from the microcomputer to the peak detector, "dumping" the peak-detecting capacitor 80 through control of the FET switch 82).

This timing procedure is utilized to enable the read channel during particular time intervals based upon completion of the previous event; for example, following detection of the anticipated "x" erased gap and the full six bits of header, the read channel is "windowed" (i.e., enabled) at the points in time when receipt of the servo-positioning bursts 36, 38 are anticipated, and during their assigned intervals. Assuming such bursts are indeed transduced and are present in the read channel during their allocated intervals of time, and are of at least the minimum threshold value required for activation of the peak detector, the counter-timer 52 will be controlled by the microcomputer to enable the read channel at the ensuing proper instant when the next significant event should occur, most particularly transducing (reading or writing) during the next area for user data, i.e., block 18'.

Thus, it should be noted that each successive different block 20 of positioning information which is

detected along the length of the recording tracks on the record member must satisfy each requirement (i.e., both time location and duration, and threshold level) for erase gap, for each header bit cell, and also for both servo-positioning bursts, following which each newly-arriving block of user data is timed anew, on a continuously-updated basis, from the end of the servo block just verified, by use of the microcomputer-controlled counter-timer 52. Therefore, no separate clocking track is recorded or utilized, and no separate clock track-transducer is used in the system. In effect, each successive block of user's data is separately clocked on a continuously-updated basis, upon receipt of each new block 20 of servo information. As indicated, the system controls not only the data read channel, by which previously-recorded user data may be read out from the recording track, but also, and perhaps more importantly, controls the user's data write capability, by enabling signals outputted from the microcomputer via port expander 48, on channels 102, 103 thereof, via gates 104 and 105, respectively. One such signal is coupled to the controller 54, and the other to the write amplifier (not shown) for double blocking of any attempted writing (i.e., recording) at any time not corresponding to qualified writing periods under the microcomputer control; thus there is a complete prohibition of the ability to record over any portion of the recording track which for any reason has not been verified by the encoded positioning signals preceding it along the track. In this manner,

the pre-recorded positioning signals are positively protected from erasure, as is the user's data field immediately following that servo block. While end-to-end transport of a complete recording track without stopping is the anticipated most typical mode, the system as disclosed will also permit intermittent or incremental operations, or back up and repeat or retry operations, since transducer position upon a track will generally be maintained by the periodic embedded servo blocks during or after such activities. Transfer from one track to another is preferably performed at an end of the tape, with the head within one of the end areas of continuously-repeating servo-positioning information, and indeed continuous microprocessor program-controlled alternating left-to-right, right-to-left track-to-track operation is anticipated as one of the preferred modes, at least when the formatted record member is a tape, the tape serving as a backup storage device for the contents of a disc memory, or the like.

It is to be noted that the present system provides the advantage, in addition to those referred to above, of using only a single transducer head and associated analog electronics for reading all of the various recorded position information, including both header decoding and servo burst amplitude, and also for reading the user data. Additionally, the same analog-to-digital converter is used in the decoding of header address bytes and also in the relative measurement of the amplitude of each pair of servo bursts for positioning purposes.

CLAIMS

1. A servo-tracking data record member (10) having the capacity to record and retain signal transitions recorded thereon, and having a plurality of generally parallel recording tracks (I-VII) comprised at least in part by lines of pre-recorded, dedicated tracking records (20), said tracking records comprising a digitally-encoded header portion (32, 34) embodying a coded signal pattern uniquely identifying the particular recording track embodying that header, and said tracking records further comprising track-centring servo signals (36, 38) including at least a pair of amplitude-encoded signal transitions disposed on opposite sides of each such track at a predetermined position along the recording track with respect to the said header.

2. A servo-tracking data record member as claimed in Claim 1 in which the recording tracks have beginning (14) and ending (16) regions, and at least said beginning regions comprise a plurality of sequential, repetitive, tracking records (20).

3. A servo-tracking data record member as claimed in Claim 1 or Claim 2 in which the recording tracks include repetitions of said tracking records (20) at spaced intervals along a track between said beginning and ending regions (14, 16).

4. A servo-tracking data record member as claimed in any of Claims 1 to 3 in which the digitally-encoded header portion (32, 34) comprises a binary-type coded track address uniquely identifying each track from the others, and said binary-type coded track address comprises bit cells (A-F) containing recorded transitions whose duration determines the code value of the different bit cells.

5. A servo-tracking data record member as claimed in Claim 4 in which the said recorded transitions of the bit cells have a different duration than that of the said track-centring servo signals.

6. A servo-tracking data record member as claimed in any of Claims 1 to 5 in which the servo signals (36, 38) are located at a particular clocked interval following their respective header (32, 34).

7. A servo-tracking data record member as claimed in any of Claims 1 to 6 in which the header portions (32, 34) recorded on adjacent tracks are disposed in different and non-registering lateral positions with respect to one another and are at different positions from one another along the length of their respective tracks.

8. A method of identifying a particular one of a number of generally parallel recording tracks (I-VII) disposed laterally adjacent one another and extending longitudinally in the direction of motion of a movable record member (10), and centring a transducer (40) upon the identified track, characterised by:

transducing sequentially-repetitive header signals (32, 34) recorded along a given track of said recording member, to reproduce such signals; sampling the said reproduced signals at predetermined intervals (A(1) to F(3)) to determine a particular signal parameter at such intervals; digitally assembling the signal parameters so determined to form a digital code symbol; comparing said code symbol to a reference symbol which uniquely identifies a particular recording track, to determine whether said given track from which signals have been transduced corresponds to said particular track; and, at least in significant part as a function of the said determination made by said comparing step, thereafter detecting servo-positioning signals (36, 38) recorded generally along said given track, and utilizing such signals to centre a transducer upon said track.

9. A method as claimed in Claim 8 which includes utilizing said positive comparison to initiate a precisely-timed interval, and enabling said transducing and servo-positioning means at a particularly-timed point in said interval.

10. A method as claimed in Claim 9 which includes enabling said transducing and servo-positioning means at two separate ones of said particular points in said precisely-timed interval and accessing two different servo-positioning signal blocks recorded at correspondingly-timed different points along said recording track.

11. A method as claimed in Claim 9 or Claim 10 which includes monitoring transduced servo-positioning signals and verifying the presence of such signals by use of a required minimum amplitude as a standard, transduced record signals having an amplitude lower than said minimum being considered as non-signals in the step of servo-positioning said transducer.

12. A method as claimed in any of Claims 8 to 11 which includes detecting the presence along said track on said record member of a particular recording characteristic appearing at the start of a recorded header, and initializing certain means used in said step of sampling said header signals as a function of such detection.

13. A method as claimed in any of Claims 8 to 12 which includes using said signal samplings by assigning binary-type digital valuations to certain such signal samplings on the basis of relative signal presence at the said particularly-timed points where sampling occurs.

14. A method as claimed in Claim 13 which includes assigning a first binary-type digital valuation to certain signal samplings which are determined as being present at a first such timed point but not present at a second and ensuing timed point.

15. A method of identifying and tracking along a particular one of a number of generally parallel recording tracks (I-VII) disposed side-by-side and extending lengthwise in the direction of travel of a

movable record member (10), characterised by the steps of seeking a track-identifying header record (32, 34) by transducing recorded signals located along said track, and using a predetermined signal parameter as a determinative standard to select header signals from other transduced signals; selecting transduced header signals by using as said parameter at least a predetermined minimum signal magnitude, and omitting from particular track-identifying use transduced signals having a lesser magnitude than said minimum; decoding the selected header signals to identify a given such track; transducing positioning signals (36, 38) recorded generally along the identified track by use of the same transducer used to transduce said header signals, and using such transduced positioning signals in a servo system to centre the said transducer upon said track.

16. A method of recording data on and reproducing such data from a particular one of a number of generally parallel recording tracks (I-VII) disposed side-by-side and extending lengthwise in the direction of travel of a movable record member (10), characterised by: seeking a track-identifying header record (32, 34) by using a transducer (40) positioned in transducing proximity to said track to reproduce recorded signals located along said track, monitoring such transduced signals to detect the presence of a particular signal condition therein, detecting such a particular signal condition, and using such detection to indicate the position along the accessed track of a recorded track-identifying header; operatively enabling header-read circuitry for a particular ensuing time interval in

response to detection of said particular signal condition; monitoring signals from said header-read circuitry during said time interval and logically evaluating signals accessed during said interval to verify conformance of such signals to a known header signal pattern; using a verified header signal pattern to initiate a second timed interval and during said second timed interval detecting servo-tracking signals (36, 38) recorded along said track; and using the detection of said servo-tracking signals during said second timed interval to initiate a third timed interval for data-signal recording or reproduction (18) along said track during such third timed interval.

17. A method as claimed in Claim 16 which includes timing each of said time intervals by using an internal non-recorded clock source, selectively accessing said internal clock source to time said intervals in response to particular transduced signal conditions.

18. A method as claimed in Claim 17 which includes separately timing the interval of each of a plurality of separate fields of said data signals by separately accessing said internal clock source prior to each such different data field interval by separate detection and verification of a separate recorded track address header located ahead of each such different data field along said track.

19. A method of identifying and determining the instantaneous position of a transducer with respect to the length of a particular one of a number of generally parallel recording tracks (I-VII) disposed side-by-side and extending lengthwise in the direction of travel of a movable record member (10), characterised by: seeking a track-identifying header record (32, 34) by using a transducer (40) positioned in transducing proximity to said track to reproduce recorded signals located along said track, using a predetermined signal parameter detected in the reproduced signals as a determinative standard to designate the beginning of such a header record; decoding a track address encoded in said header; and decoding a station address signal recorded proximate to said header and indicative of the location along said track of said station address recording, thereby indicating the position of the transducer with respect to the length of the track at the time such signal was transduced.

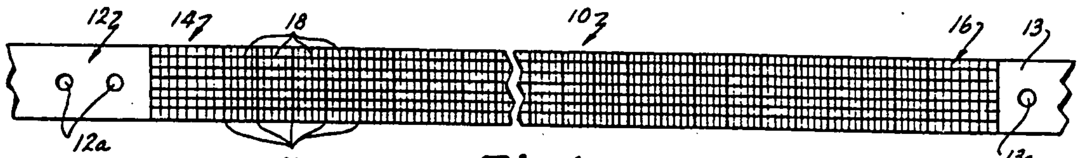


Fig. 1.

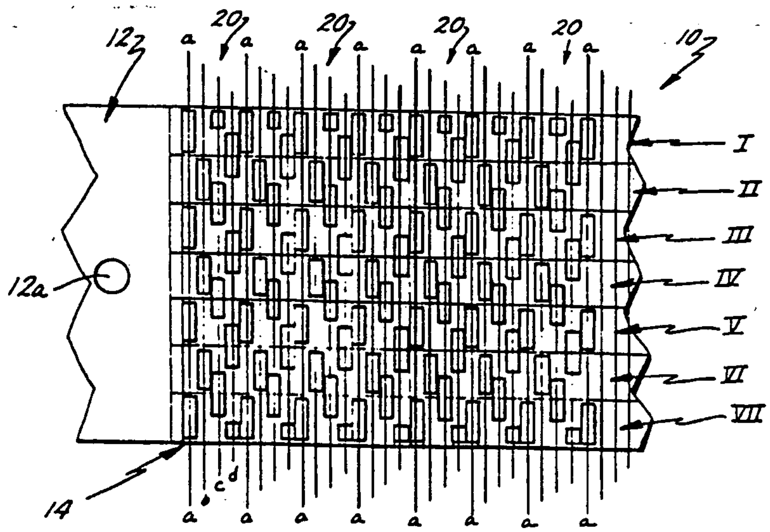


Fig. 2.

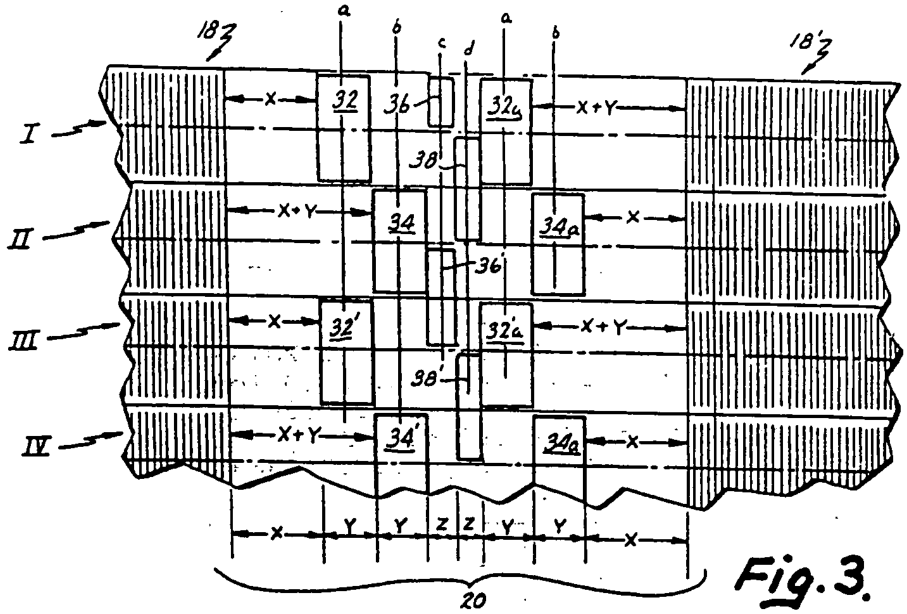


Fig. 3.

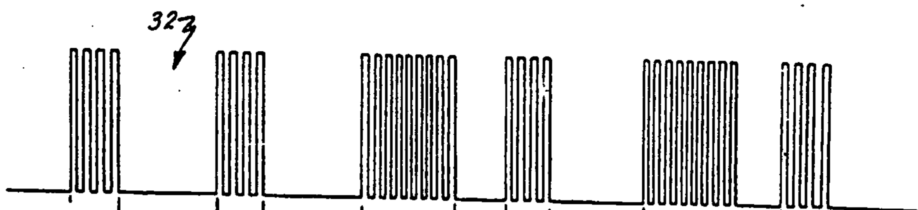


Fig. 4a

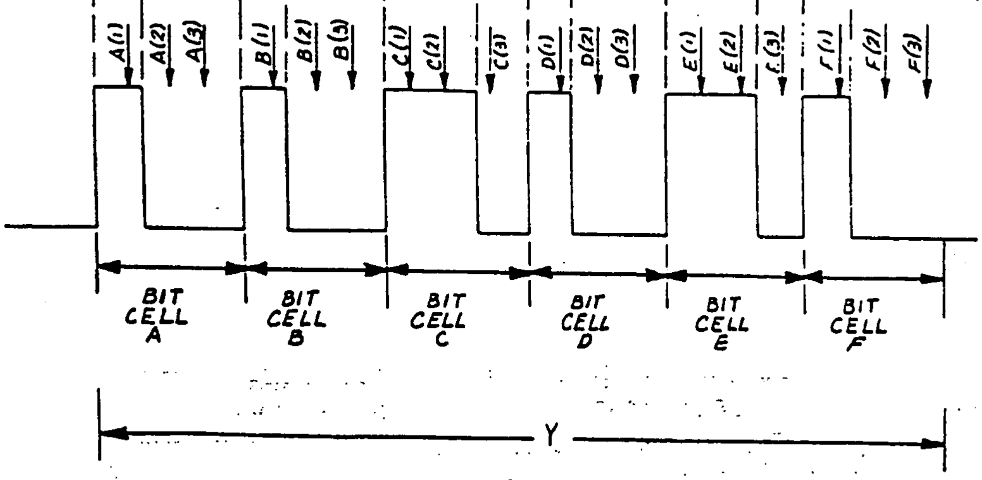


Fig. 4b.

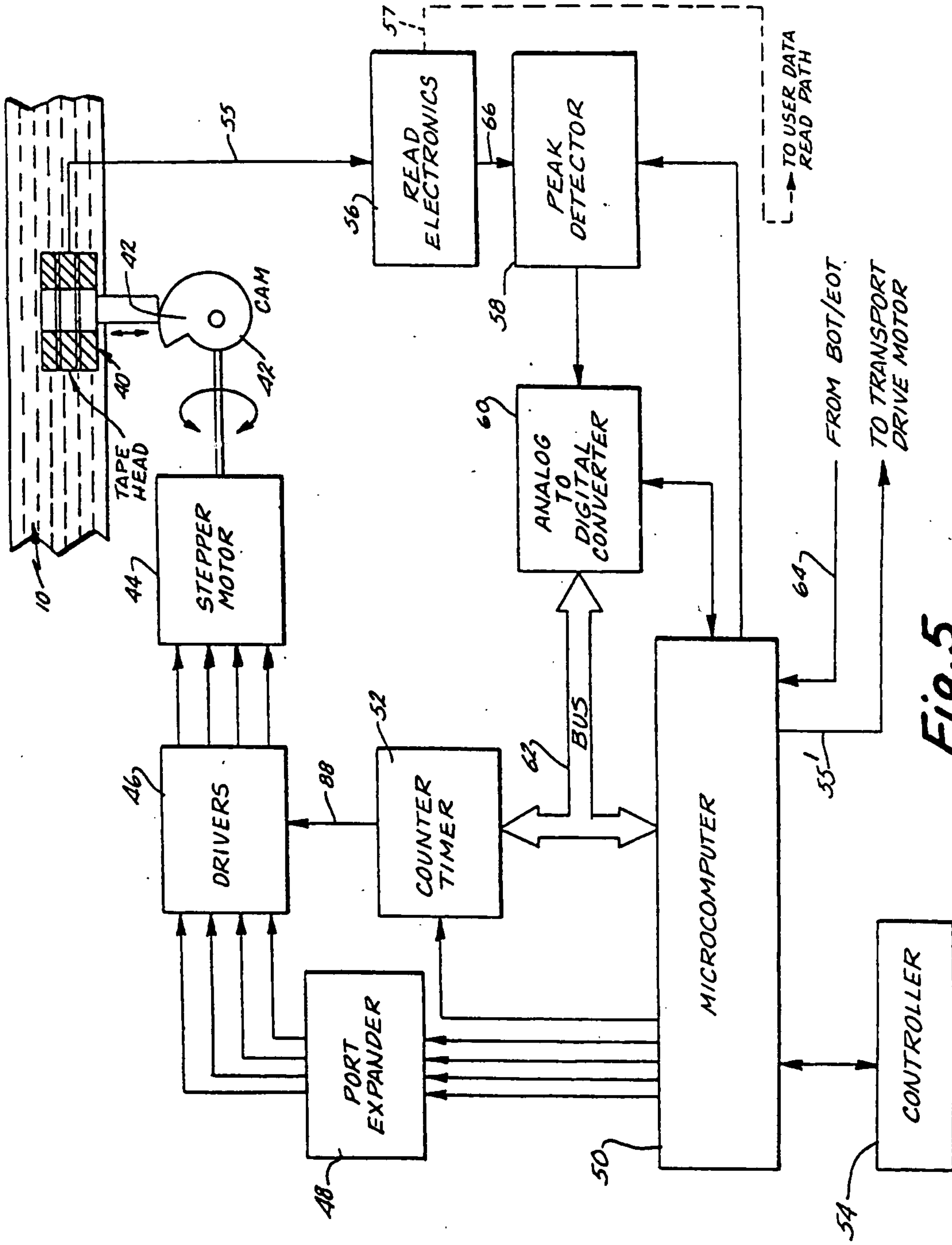

TAPE HEAD
CAM
STEPPER MOTOR
READ ELECTRONICS
PEAK DETECTOR
TO USER DATA READ PATH
ANALOG TO DIGITAL CONVERTER
FROM BOT/EOT
TO TRANSPORT DRIVE MOTOR
BUS
DRIVERS
COUNTER TIMER
MICROCOMPUTER
PORT EXPANDER
CONTROLLER
10
40
42
44
46
48
50
52
54
55
55'
56
57
58
60
62
64
66
88

Fig.5.

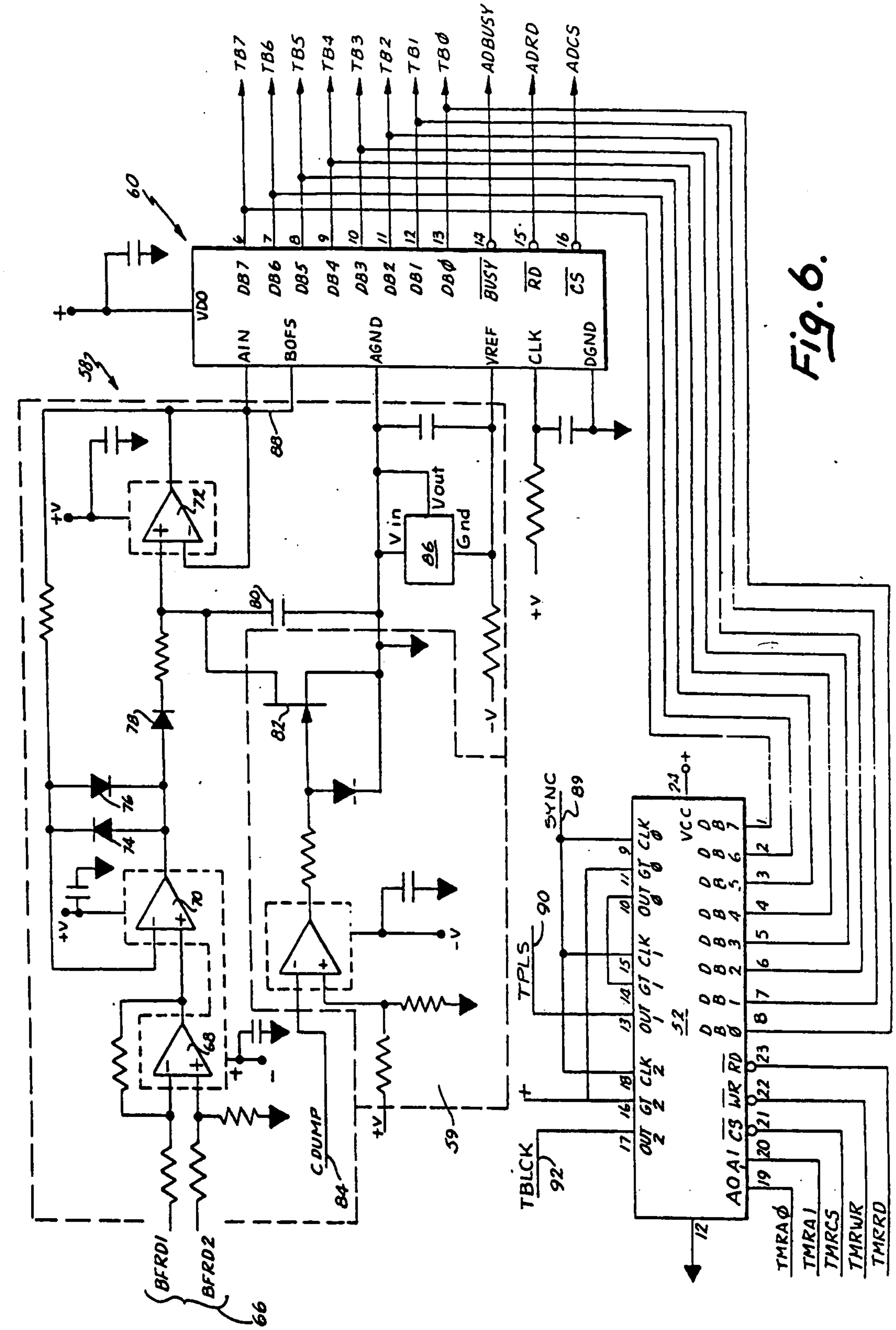
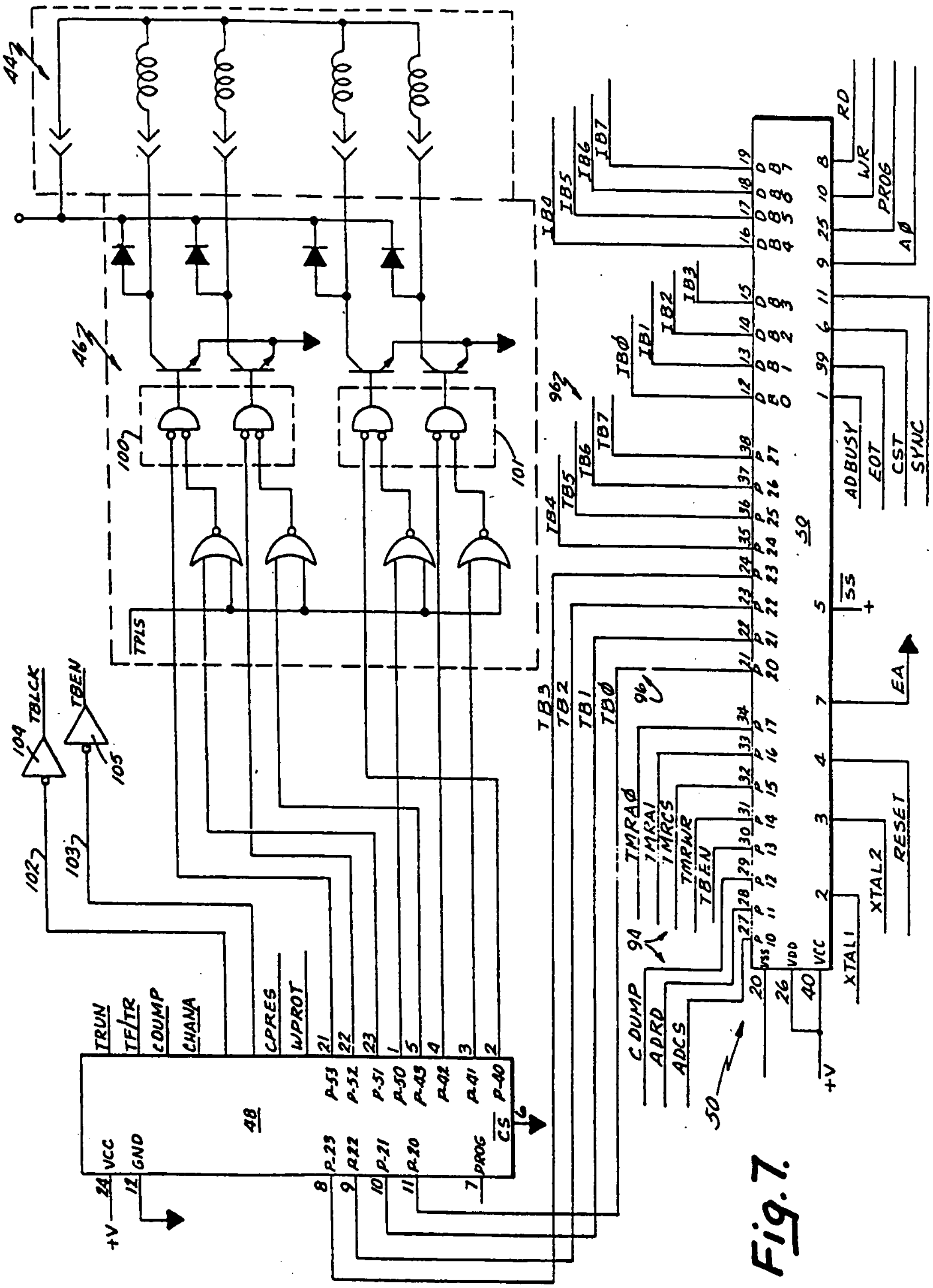

TB7
TB6
TB5
TB4
TB3
TB2
TB1
TBØ
ADBUSY
ADRD
ADCS
60
VDO
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DBØ
BUSY
RD
CS
AIN
BOFS
AGND
VREF
CLK
DGND
58
88
72
Vin
Vout
86
Gnd
80
82
78
76
74
70
68
CDUMP
84
59
BFRD1
BFRD2
66
SYNC
89
TPLS
90
TBLCK
92
52
VCC
TMRAØ
TMRA1
TMRCS
TMRWR
TMRRD

Fig.6.



TRUN
TF/TR
CDUMP
CHANA
CPRES
WPROT
48
VCC
GND
PROG
CS
+V
TBLCK
TBEN
TPLS
C DUMP
ADRD
ADCS
TMRAØ
TMRA1
TMRCS
TMRWR
TBEN
XTAL1
XTAL2
RESET
ADBUSY
EOT
CST
SYNC
EA
RD
WR
PROG
AØ
IBØ
IB1
IB2
IB3
IB4
IB5
IB6
IB7
TBØ
TB1
TB2
TB3
TB4
TB5
TB6
TB7

Fig. 7.

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 3)
Y	EP-A-0 000 946 (HEWLETT-PACKARD) * figures 4-11; page 6, last paragraph to page 13, line 17 *	1,4-6, 15-16, 17	G 11 B 5/58 G 11 B 21/10 G 11 B 5/09
Y	US-A-4 149 201 (BURRGOUGHS) * figures 3-5; column 6, line 7 to column 8, line 8 *	1,4,6-7,15-16,17	
A	GB-A-2 058 431 (DIGITAL EQUIPMENT CORP.) * figures 2-4; page 2, line 130 to page 3, line 115 *	1-5,16-19	
A	NEUES AUS DER TECHNIK, no.3, June 15, 1979 "Servospurkodierungsmuster", page 4	1	TECHNICAL FIELDS SEARCHED (Int Cl 3)
A	US-A-3 919 697 (WALKER)	1	G 11 B
A	US-A-3 983 577 (ITO AND KITAMURA)	1	
A	US-A-3 179 924 (AUYANG et al.)	1	
A	FR-A-2 417 824 (HONEYWELL-BULL)	1	

-/-

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-10-1982	CARTRYSSE A.A.H.

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	IBM TECHNICAL DISCLOSURE BULLETIN, vol.20, no.5, October 1977, New York (US) J.C. DENNISON et al.: "Rotating record disk initialization for sector servoing", pages 1789-1791 ---	1	
A	PATENTS ABSTRACTS OF JAPAN, vol.6, no.8, January 19, 1982, (P-98) [886] & JP - A - 56 134 371 (MITSUBISHI DENKI K.K.) (21-10-1981) -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

The present search report has been drawn up for all claims

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